**BELLCOMM, INC.**
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: 1975 Venus Lightside Flyby-Ascent of Venus Surface Sample Return (VSSR) Probe, Delta V Requirements - Case 233

DATE: May 26, 1967

FROM: J. J. Schoch

## ABSTRACT


A study of Venus ascent trajectories for a Venus Surface Sample Return probe was performed. Due to the high density of the planetary atmosphere (Figures 1 and 2) a five stage launch vehicle is required. The trajectory profile is shown on Figures 3 and 4. During the first stage flight the vehicle reaches only a velocity of about 1,500 ft/sec out of a theoretical ΔV of 9,400 ft/sec. Total drag losses are 4,430 ft/sec. The calculations were limited to the low density atmospheric model.

It is concluded that due to the very high drag losses experienced, alternative propulsion means that make use of the planet's atmosphere should be investigated.





N79-71794

(NASA-CR-154430) THE 1975 VENUS LIGHTSIDE FLYBY-ASCENT OF VENUS SURFACE SAMPLE RETURN (VSSR) PROBE, DELTA V REQUIREMENTS (Bellcomm, Inc.) 9 p

Unclas
00/12 12481


[redacted]

**BELLCOMM, INC.**
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: 1975 Venus Lightside Flyby-Ascent of Venus Surface Sample Return (VSSR) Probe, Delta V Requirements - Case 233

DATE: May 26, 1967

FROM: J. J. Schoch

# MEMORANDUM FOR FILE

## Introduction

This study applies to the 1975 Venus Lightside Flyby Mission described in Reference 1. The spacecraft passes the planet at an altitude of 270 nautical miles at a velocity of 35,920 ft/sec. The Venus Surface Sample Return (VSSR) probe mission mode is identical in concept to the one of the MSSR probe described in Reference 2. Due to the denser atmosphere of Venus and the higher gravity, the delta V requirements for an ascent from the Venerean surface are much larger than they are for a Martian probe.

The results are presented in terms of $\Delta V$ required to go to a 100 nautical mile altitude circular orbit since the additional losses in going from circular orbit to the hyperbolic flyby trajectory are relatively small.

## Vehicle Details

It was found that a five stage vehicle is required to rendezvous with the spacecraft. The first three and part of the fourth are required to go to a 100 nautical mile circular orbit. The weights of the first four stages were assumed as follows:

| STAGE | STRUCTURE & ENGINE WEIGHT (LBS) | PROPELLANT WEIGHT (LBS) |
|---|---|---|
| 1 | 8,500 | 77,000 |
| 2 | 2,000 | 18,000 |
| 3 | 490 | 4,370 |
| 4 | 170 | 946 (505 lbs. unburned) |

For the purpose of computing drag a Saturn IB like configuration was assumed having a frontal area of 88 $ft^2$ at the first stage and 32 $ft^2$ at the second stage.

[redacted]

The thrust to initial weight ratios and the specific impulses of the single stages were assumed as follows:

| STAGE 1 | STAGE 2 | STAGE 3 | STAGE 4 |
|---|---|---|---|
| T/W 1.35 | 1.49 | 1.77 | 1.53 |
| ISP 250 | 300 | 305 | 305 |

The Venerean Atmosphere

Three atmospheric models are provided in Reference 3, a low, medium, and high density model. For reference purposes these atmospheres are shown on Figures 1 and 2. The sea level density is between 3 and 16 times higher on Venus than it is on Earth and the sea level pressure is between 5 and 40 times higher on Venus.

The probe ascent trajectories were limited to the low density atmospheric model.

Trajectory Details

The trajectory profile is as follows: Initial vertical rise for 10 seconds at which time the vehicle is slightly tilted. Gravity turn for the remainder of the first and during the complete burn of the second stage followed by a linear tangent guidance law for the remaining two stages. The vehicle is then parked on a 100 nautical mile circular orbit. The runs were optimized for initial tilt angle and first stage thrust.

Results and Conclusions

The trajectory profile is shown on Figure 3, a plot of velocity and dynamic pressure vs. time, and Figure 4, a plot of flight path angle and altitude vs. time. At first stage cut-off the conditions were as follows:

| | |
|---|---|
| Actual Velocity : | 1,500 Ft./Sec. |
| Drag Loss : | 3,800 Ft./Sec. |
| Gravity Loss : | 4,084 Ft./Sec. |
| Total First Stage ΔV: | 9,384 Ft./Sec. |

First stage cutoff occurs at 143 seconds. The vehicle has reached at that time an altitude of 98,000 ft. and the flight path angle is 73°, i.e., first stage flight is almost vertical. Upon reaching earth orbital conditions, the losses are as follows:

| | | |
|---|---|---|
| Orbital Velocity | : | 23,781 Ft./Sec. |
| Drag Loss | : | 4,430 Ft./Sec. |
| Gravity Loss | : | 7,321 Ft./Sec. |
| Total $\Delta V$ | : | 35,532 Ft./Sec. |

To rendezvous with the hyperbolic flyby spacecraft approximately 14,000 ft/sec more are required. Drag losses were computed by integrating the quantity Drag/Mass over the time. The maximum dynamic pressure is 1,495 lbs/ft$^2$. It occurs at 53,000 feet altitude.

These results apply only to the low density atmospheric model. Launch from the densest model atmosphere, which is five times denser, appears almost impossible.

It may be concluded that a rocket take-off from Venus is prohibitively expensive and that other propulsion means that make use of that planet's dense atmosphere should be investigated.

J. J. Schoch

J. J. Schoch

1013-JJS-pdm

Attachment
References 1-3
Figures 1-4

## REFERENCES


1. "1975 Venus Lightside Flyby-Trajectory Surface" - Case 103-2, dated December 29, 1966 by A. A. VanderVeen.
2. "Ascent of Mars Surface Sample Return (MSSR) Probe-Delta V Requirements" - Case 103-2, dated January 5, 1967 by J. J. Schoch.
3. "Space Environment Criteria Guidelines for Use in Space Vehicle Development," TM-53-273 by R. E. Smith, Marshall Space Flight Center, Huntsville, Alabama, dated, May 27, 1965.

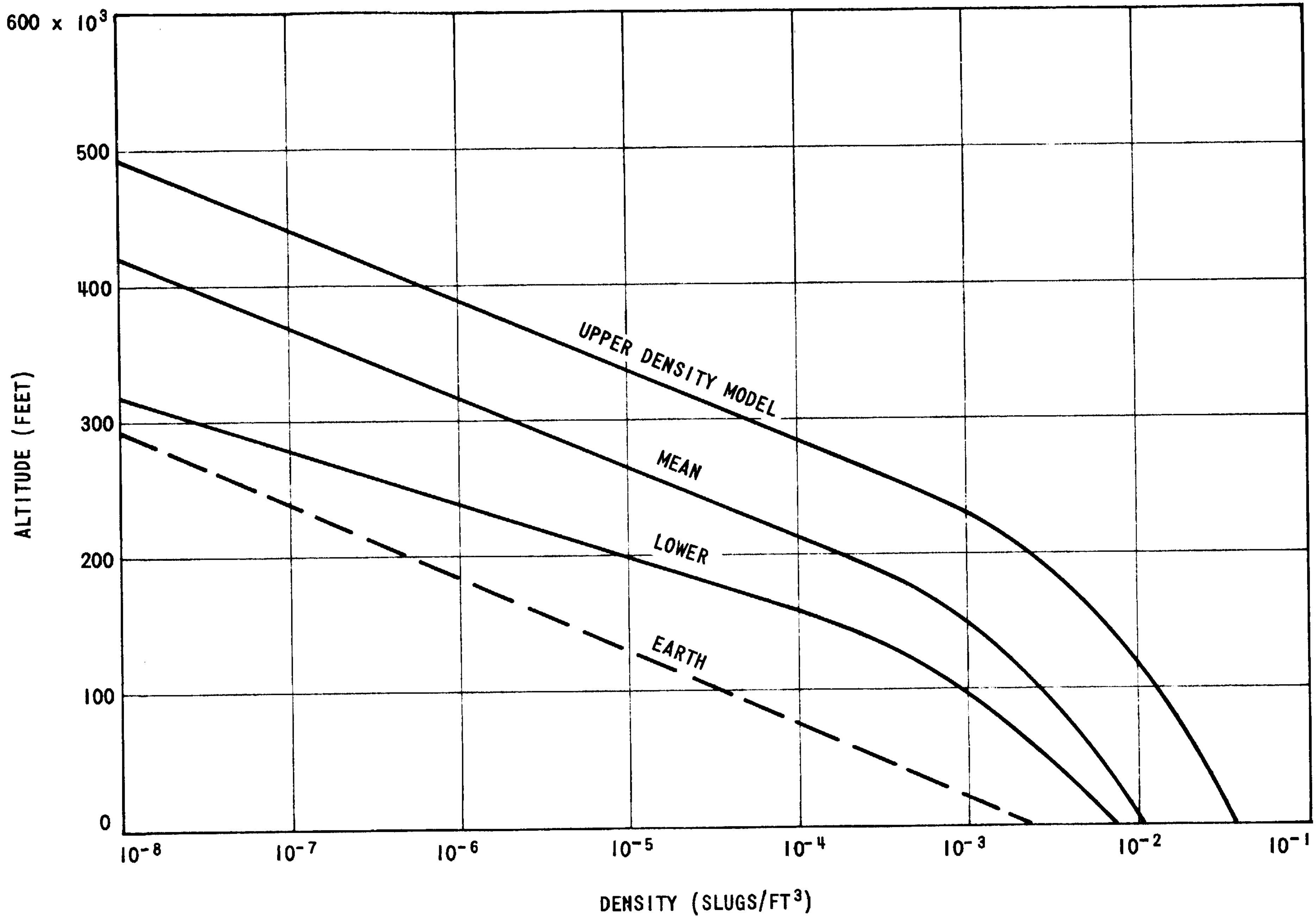


FIGURE 1 - VENUS ATMOSPHERE: DENSITY

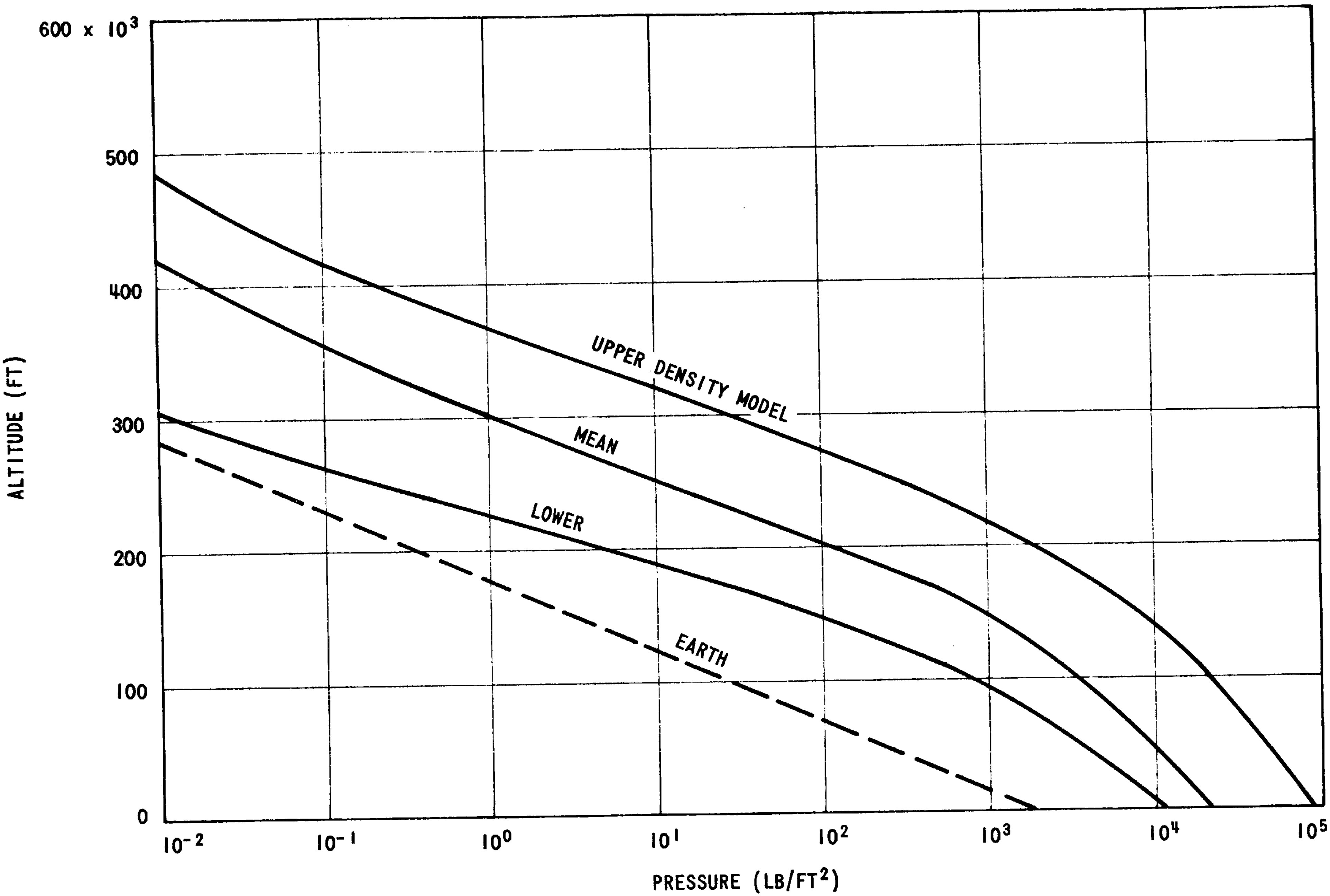


FIGURE 2 - VENUS ATMOSPHERE: PRESSURE

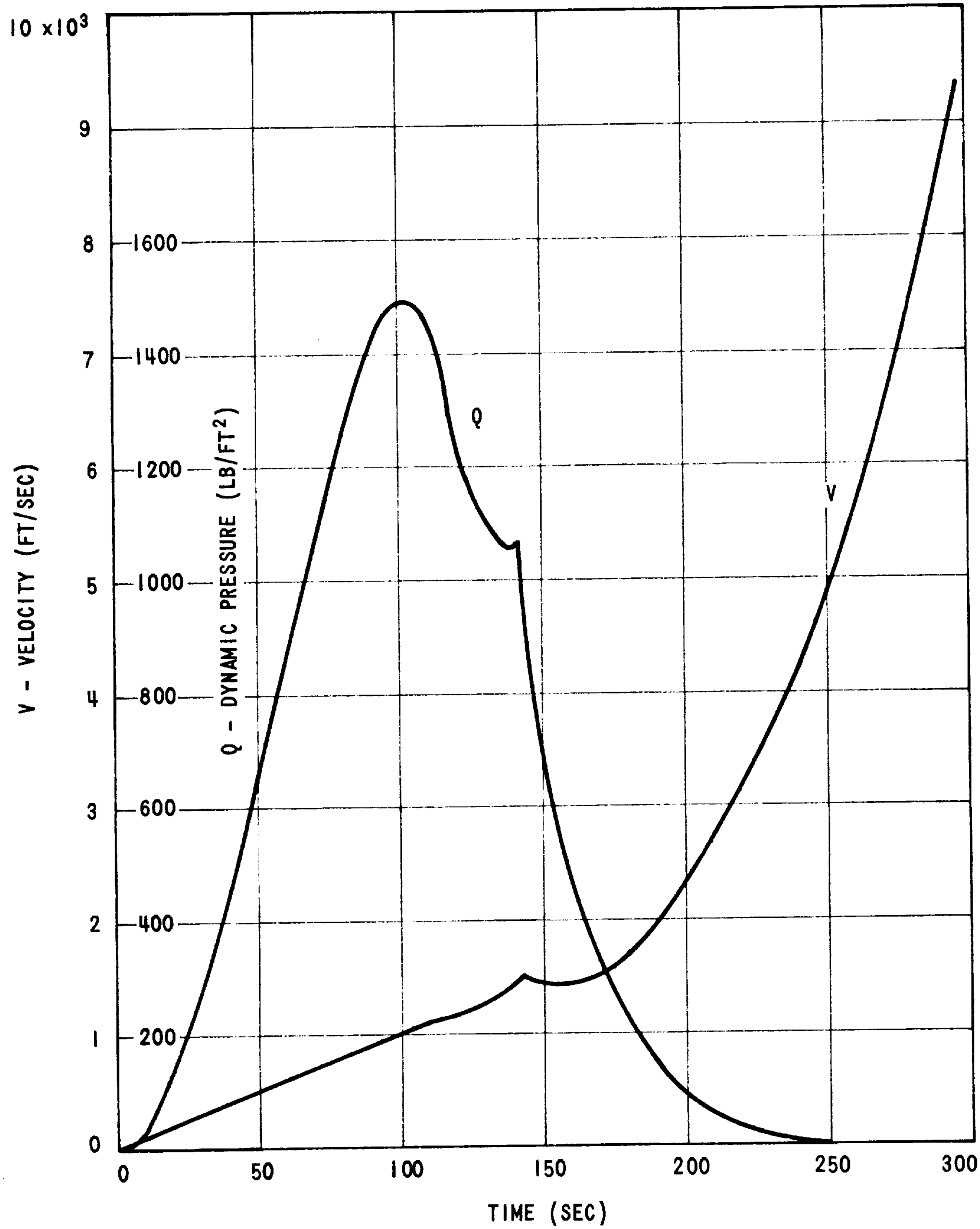


FIGURE 3 - V.S.S.R. TRAJECTORY PROFILE; FIRST AND SECOND STAGE VELOCITY AND DYNAMIC PRESSURE VS. TIME

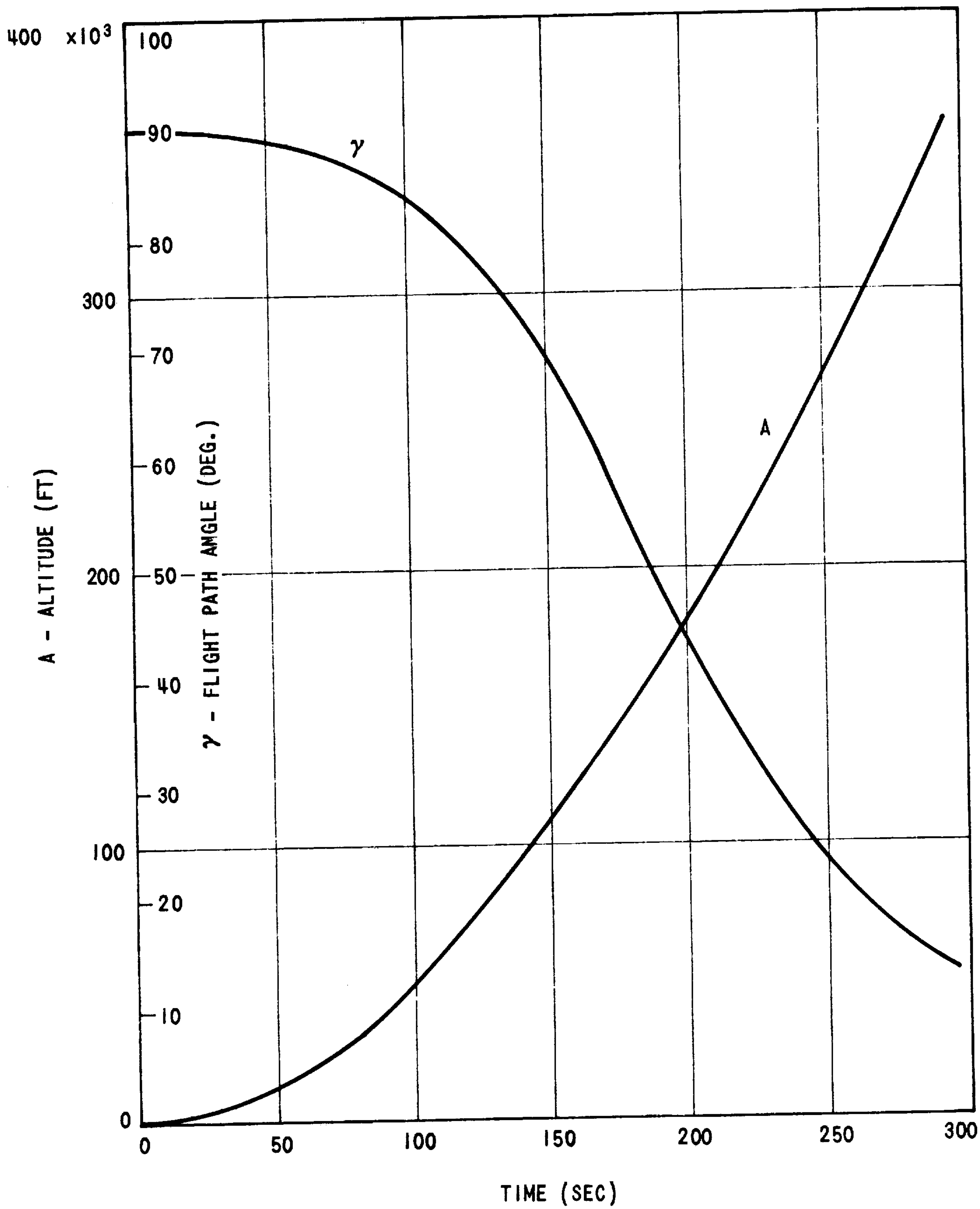


FIGURE 4 - V.S.S.R. TRAJECTORY PROFILE; FIRST AND SECOND STAGE ALTITUDE AND FLIGHT PATH ANGLE VS. TIME

BELLCOMM, INC.

Subject: 1975 Venus Lightside Flyby-Ascent of Venus Surface Sample Return (VSSR) Probe, Delta V Requirements Case 233

From: J. J. Schoch

## Distribution List

NASA Headquarters

Messrs. P. E. Culbertson/MTL
J. H. Disher/MLD
F. P. Dixon/MTY
R. W. Gillespie/MTY
M. Gruber/MTY
W. L. Haberman/MTY
E. W. Hall/MTS
W. J. Hamon/MTY
T. A. Keegan/MA-2
D. R. Lord/MTD
M. J. Raffensperger/MTE
L. Reiffel/MA-6
A. D. Schnyer/MTV
G. S. Trimble/MT

MSC

Messrs. C. Covington/ET-23
J. Funk/FM-8
G. C. Miller/ET-23
M. A. Silveira/ET-25
W. E. Stoney, Jr./ET
J. M. West/AD

MSFC

Messrs. J. G. Austin/R-P&VE-MCP
R. J. Harris/R-AS-VP
E. D. Messer/R-OM-V
B. G. Noblitt/R-AERO-DPF
F. L. Williams/R-AS/DIR

KSC

Messrs. R. J. Cerrato/MC
J. P. Claybourne/EDV-4
R. C. Hock/PPR-2
N. P. Salvail/MC

Bellcomm

Messrs. G. M. Anderson
A. P. Boysen
J. P. Downs
D. R. Hagner
P. L. Havenstein
J. J. Hibbert
W. C. Hittinger
B. T. Howard
D. B. James
H. S. London
K. E. Martersteck
R. K. McFarland
J. Z. Menard
I. D. Nehama
G. T. Orrok
I. M. Ross
R. L. Selden
R. V. Sperry
T. H. Thompson
J. M. Tschirgi
R. L. Wagner
All Members, Div. 101
Department 1023
Library
Central File